Effect Of Bio-Control Agents and Phosphorus Doses on Growth and Yield Performance Chickpea (*Cicer Arietinum* L.)

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***Abstract*—A field experiment was conducted in experimental farm of College of Agriculture, Tripura during *Rabi* season 2023-2024 to investigate the effect of bio-control agents and phosphorus doses on growth and yield performance chickpea (*Cicer arietinum* L.). The experiment was laid out in split plot design with three replications and sixteen treatments consisting of four levels of bio-control agents in main plot (No inoculation, *Pseudomonas fluorescens inoculation*, *Trichoderma harzianum* inoculation and combined inoculation of *Pseudomonas fluorescens* and *Trichoderma harzianum*) and four levels of phosphorus in sub plot (No phosphorus, 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 80 kg P_2O_5 ha^{-1}). The results of the experiment indicated that the combined application of bio-control agents with phosphorus doses significantly influence the growth and yield of chickpea. In the treatment combination of bio-control agents (*Pseudomonas fluorescens* and *Trichoderma harzianum*) with phosphorus dose 80 kg P_2O_5 ha^{-1} recorded maximum growth performance such as plant height (47.48 cm), number of primary (7.48) and secondary branches (10.91), dry matter accumulation (631.88 g m^{-2}), crop growth rate (8.56 gm^{-2} day^{-1}) and yield attributes such as no. of pods per plant (22), seed yield (1186.3 kg ha^{-1}), stover yield (1888.1 kg ha^{-1}) and harvest index (38.81%) respectively. Growth parameters and yield attributes showed equivalent result in treatment combination of bio-control agents with phosphorus doses 60 kg P_2O_5 ha^{-1}. So best treatment identified in the study was the combination of** bio-control agents **(*Pseudomonas fluorescens* and *Trichoderma harzianum*) with a phosphorus dose 60 kg P_2O_5 ha^{-1}, which significantly enhanced chickpea growth and yield respectively.**

***Index Terms*—Bio-control agents, phosphorus, yield, benefit cost ratio.**

I. INTRODUCTION

Pulses occupy a significant position in Indian agriculture, serving as a vital source of protein, vitamins, and minerals in predominantly vegetarian Indian diet. Pulses are often referred to as "poor man's meat" and "rich man's vegetables" due to their affordability and high nutritional value, making them accessible to all socioeconomic groups. Among the pulses Chickpea is an important prime pulse crop in India. Chickpea belongs to family leguminoceae and contains 17% to 23% protein (Kumar *et al.,* 2014), 52-70 % carbohydrate, 4-10 % fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins. The germinated seeds are recommended to cure scurvy. Malic and oxalic acids collected from green leaves are prescribed for intestinal disorder. "India is the largest acreage holder and producer of chickpea in the world. The desi chickpea contributes to around 80% and the Kabuli chickpea around 20% of the total production. In India, it is cultivated in 10.56 million hectares with an annual production of 11.23 million tonnes with productivity of 1063 kg ha^{-1} (Anonymous, 2020-21). According to Indian institute of pulses research, in Tripura chickpea cover area 0.2 thousand ha, production 0.1 thousand tones and productivity 799 kg per hectare in 2011-12. Chickpea supports sustainable agriculture by improving soil properties and fixing 25–30 kg of nitrogen per hectare, reducing the need for chemical fertilizers (Reddy & Reddy, 2005). Phosphorus, a vital macronutrient, enhances root development, nodulation, flowering, and ripening.

Seed treatment with bio-control agents controls soil-borne pathogenic infections and reduces the risk of host susceptibility to diseases. *Pseudomonas fluorescens* being a key organism is known for its plant growth promotion and disease management properties. Phosphorus solubilizing micro-organisms are the main engine to promote the circulation of P between soil and plants (Bargaz, 2021). *Trichoderma* is a bio-control agent which is able to solubilize soil nutrients and it also has p solubilizing properties (Song *et al.,* 2023*). T. harzianum* was found to be most efficient organic *P mobilizer* as compared to the other fungi (Tarafdar *et al.,* 2003). *Trichoderma harzianum* is one efficient biocontrol agent that is successfully used to suppress *Fusarium* wilt (Khan *et al.,* 2004; Dubey *et al.,* 2007). In Tripura demand of chickpea is high but production is very less. The farmers are not interested to cultivate chickpea due to less yield. Most of the crops damage due to disease. So, in this present experiment two bio-control agents were used along with different phosphorus doses to observe the effects on chickpea production.

II. MATERIALS AND METHODS

The field experiment was carried out in the experimental farm of College of Agriculture, Tripura, during *rabi* season of 2023-2024 to investigate the effect of bio-control agents and phosphorus doses on growth and yield performance of chickpea (*Cicer arietinum* L.). The experimental field was situated at 23°54'25" N latitude, 91°18'44" E longitude and an altitude of 52 meters above mean sea level. The soil of the experimental field was sandy loam in texture having pH 5.1, low in available nitrogen (177.11 kg ha^{-1}) and phosphorus (6.16 kg ha^{-1}), potassium (147.54 kg ha^{-1}), organic carbon (0.43 %). The experiment was laid out in split plot design with three replications, assigning sixteen treatments consisting of four levels of bio-control agents in main plot (No inoculation, *Pseudomonas fluorescens inoculation*, *Trichoderma harzianum* inoculation and combined inoculation of *Pseudomonas fluorescens* and *Trichoderma harzianum*) and four levels of phosphorus in sub plot (No phosphorus, 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 80 kg P_2O_5 ha^{-1}). Recommended doses of fertilizers (25:40 N and K_2O kg ha^{-1}) were applied in all the treatments. There were 48 plots and the plot size was 9 m^2 (3m×3m). Chickpea crop was sown at 10 cm plant to plant and 30 cm row to row spacing. Temperature range during experimental period was 12 ºC to 27 ºC and total rain fall received 103.7 mm. All the growth and yield attributes were taken at 30 DAS, 60 DAS, 90 DAS and at harvest using standard procedure and data were statistically analyzed as procedures given by (Panse and Sukhatme., 1967).

III. RESULT AND DISCUSSION

Growth attributes

The results presented in Table 1 and Table 2 indicated that combinations of bio-control agents and phosphorus levels had significant impact on growth parameters such as plant height (cm), dry matter accumulation (g m^{-2}) and crop growth rate (g m^{-2} day^{-1}), number of primary and secondary branches per plant and root length. From Table 1 it is observed that the plant height, dry matter accumulation (g m^{-2}) and crop growth rate (g m^{-2} day^{-1}) significantly influenced by different bio –control agents and their combination at 30 DAS, 60 DAS, 90 DAS and harvest but plant height at 30 DAS was non-significant. The maximum plant height (42.45 cm), dry matter accumulation (501.03 g m^{-2}), and crop growth rate (7.20 g m^{-2} day^{-1}) were recorded by B_3 treatment i.e., seed inoculated with both the bio-control agents *Pseudomonas fluorescens* and *Trichoderma harzianum* and lowest was recorded by B_0 treatment i.e., no seed inoculation. Subplot treatment i.e., different phosphorus doses also showed significant influence on plant height, dry matter accumulation and crop growth rate and maximum plant height (40.39 cm in P_3), dry matter accumulation (435.61 g m^{-2} in P_3) and crop growth rate (5.96 g m^{-2} day^{-1} in P_3) were observed under P_3 treatment (Phosphorus @ 80 kg ha^{-1}.) and lowest were observed under control treatment (no phosphorus fertilizer). Plant height at all growth stages, dry matter accumulation at harvest stage and crop growth rate at 30 DAS to 60 DAS and 60 DAS to 90 DAS were statistically at par with P2 treatment (phosphorus @ 60 kg ha^{-1}).

Interaction effects on plant height were not significant at 30 DAS, 60 DAS, 90 DAS and harvest though highest plant height (47.48 cm) was recorded in treatment B_3P_3 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 80 kg P_2O_5 ha^{-1}) and lowest height was recorded in the treatment B_0P_0 i.e., control. Interaction effect on dry matter accumulation was significant at 30 DAS, 60 DAS and 90 DAS showed in Table 1(a). Maximum dry matter accumulation (631.88 g m^{-2}) was observed in treatment B_3P_3 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 80 kg P_2O_5 ha^{-1}) and minimum in B_0P_0 i.e., control treatment. Crop growth rate rate was significant at 90 DAS to harvest showed in Table 1 (b). Maximum crop growth rate (8.56 g m^{-2} day^{-1}) was recorded in treatment B_3P_3 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 80 kg P_2O_5 ha^{-1}) and minimum at control (B_0P_0) represent. Singh *et al.* (2018) reported that combined application bio-control agent with phosphorus doses enhance the growth of plant.

Data presented in Table 2 revealed that the number of branches per plant and root length of chick pea plant significantly influenced by different bio –control agents and their combination. Maximum numbers of primary (6.56) and secondary branches per plant (9.15) and highest root length (21.49 cm) were recorded in B_3 treatment (*Pseudomonas fluorescens* + *Trichoderma harzianum*) whereas root length was non-significant at 90 DAS. Again, in subplot treatment maximum numbers of number of primary (6.22) and secondary branches per plant (9.46), and highest root length (20.10 cm) were recorded with phosphorus @ 80 kg P_2O_5 ha^{-1} in P_3 Treatment. Application of phosphorus doses @ 80 kg ha^{-1} which is statically at par with application of phosphorus doses @ 60 kg P_2O_5 ha^{-1} parameters such as no. of primary branch at 30 DAS, 60 DAS and at harvest, secondary branch at 90 and at harvest. According to Chauhan & Raghav (2017) application of phosphorus doses significantly increase the growth parameter (plant height, branches/plant, number and shoot dry weight/plant) and also significantly influenced CGR (Singh *et al.*, 2017). Gaikwad *et al* (2021) reported that phosphate solubilizing bacteria significantly enhanced various growth attributes. Li *et al.* (2018) reported that *Trichoderma* spp. reduced disease severity and increase plant growth.

Interaction effects of different bio-control agents and different phosphorus doses had no significant impacts on number of primary and secondary branches and root length of chick pea plant at all stages of growth but number of secondary branches was significantly influenced at 90 DAS showed in table 2(a). Maximum number of primary (7.48) and secondary branch (10.91) were recorded in B_3P_3 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 80 kg P_2O_5 ha^{-1}) treatment at harvest and lowest in B_0P_0 i.e., control treatment

Yield Attributes, yield and harvest index

From the result depicted in the Table 3 it is observed that application of bio-control agents and different doses of phosphorus significantly influence no. of pods per plant, seed yield, stover yield and biological yield of chickpea but no. of seed per pods, test weight and harvest index were not significantly influenced by main plot and subplot treatments. Maximum no. of pods per plant (18.50), no. of seed per pods (1.40), test weight (178.08 g) seed yield (974.1 kg ha^{-1}), stover yield (1722.7 kg ha^{-1}), biological yield (2696.8 kg ha^{-1}) and harvest index (35.81 %) were recorded in B_3 treatment (*Pseudomonas fluorescens* + *Trichoderma harzianum*). Combined application of bio-control agents (*Pseudomonas fluorescens* + *Trichoderma harzianum*) was statically at par with solo application *Trichoderma harzianum* on yield attribute such as no. of seed per pod and stover yield. Biswas & Ali (2017) reported that both bio-control agents minimize Fusarium wilt incidence in chickpea and enhance yield under field conditions. Again, in case of different phosphorus doses, maximum no. of pods per plant (17.92), no. of seed per pods (1.42), test weight (178.43 g), seed yield (876.0 kg ha^{-1}), stover yield (1590.1 kg ha^{-1}), biological yield (2466.1 kg ha^{-1}) and harvest index (35.64 %) were recorded in P_3 (@ 80 kg P_2O_5. Minimum no. of pods per plant, test weight, seed yield, stover yield, biological yield was recorded under control condition in both main plot treatments and sub plot treatments i.e., with no inoculation and no phosphorus fertilizer but in case of no. of seed per pods and harvest index lowest values were not recorded in control treatments. Application of phosphorus doses @ 80 kg ha^{-1} which is statically at par with application of phosphorus doses @ 60 kg P_2O_5 ha^{-1} though highest no. of seed per pods, no. of pods per plant, seed yield, stover yield and harvest index were recorded with 80 kg ha^{-1} phosphorus. According to Jaiswal & Tomar (2022) application of phosphorus doses enhance the yield attribute of chickpea. Hari & Dawson (2022) also reported that phosphorus can increase yield attribute and harvest index.

Interaction effect of combine application of bio-control agents and phosphorus doses had no significant influence on no. of pods per plant, no. of seeds per pod, test weight, stover yield, biological yield and harvest index but only seed yield of chickpea was significantly influenced by interaction effects of main and subplot treatment, presented in Table 3(a). The maximum number of pods per plant, seed yield, stover yield, biological yield and harvest index of chickpea were recorded in treatment B_3P_3 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 80 kg P_2O_5 ha^{-1}) but maximum number of seeds per pod was recorded in treatment B_3P_2 (*Pseudomonas fluorescens* + *Trichoderma harzianum* with 60 kg P_2O_5 ha^{-1}). The lowest yield attributes were observed in the control treatment (B_0P_0) but in case of harvest index lowest value was recorded in B_0P_2.Goswami *et al.* (2020) reported that dual seed inoculation with PSB + *Trichoderma* which were found significantly superior to PSB and *Trichoderma* alone and with increasing levels of phosphorus increased yield and yield attributes.

IV. CONCLUSION

From the present experiment, it can be concluded that the combined application of *Pseudomonas fluorescens* and *Trichoderma harzianum* significantly influenced chickpea growth and yield. The application of phosphorus fertilizer at a rate of 80 kg ha^{-1} recorded the highest growth and yield attributes, followed by the application of 60 kg ha^{-1} of phosphorus. The combined application of *Pseudomonas fluorescens* and *Trichoderma harzianum* along with 80 kg ha^{-1} of phosphorus resulted in growth and yield performances which were equivalent to growth and yield performances recorded by combined application bio-control agents with 60 kg ha^{-1} of phosphorus. So, the combined application of *Pseudomonas fluorescens* and *Trichoderma harzianum* along with 60 kg ha^{-1} of phosphorus may be recommended to the farmers of Tripura to reduce phosphorus fertilizer cost and for profitable chickpea cultivation.

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Table 1: Effect of bio-control agents and phosphorus doses on plant height (cm), dry matter accumulation (g m^{-2}) and crop growth rate (g m^{-2} day^{-1}) of chickpea

Plant height (cm)					Dry matter accumulation (g m^{-2})				Crop growth rate (g m^{-2} day^{-1})		
Treatment	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30-60 DAS	60-90 DAS	90 DAS - harvest
Main plot (Bio-control agents)											
B_0 (No inoculation)	10.91	19.19	28.89	32.04	6.99	43.66	135.20	248.36	1.22	4.07	4.02
B_1 (*Pseudomonas fluorescens*)	11.80	20.68	30.25	34.51	9.66	56.20	160.98	283.42	1.50	4.41	4.08
B_2 (*Trichoderma harzianum*)	12.07	21.03	32.16	37.21	9.42	52.51	160.28	337.53	1.43	5.01	5.90
B_3 (Pseudomonas *fluorescencs* + *Trichoderma harzianum*)	14.08	27.43	38.36	42.45	13.39	79.34	284.78	501.03	2.19	6.34	7.20
S Em (±)	0.542	0.65	0.78	0.70	0.23	1.30	4.27	9.47	0.06	0.16	0.20
CD (5%)	NS	2.26	2.70	2.45	0.79	4.50	14.77	32.78	0.22	0.56	0.7
Sub plot (Phosphorus level)											
P_0 (Control)	10.04	17.90	25.53	30.34	5.29	32.37	99.34	209.43	0.90	4.08	3.92
P_1 (P_2O_5 @ 40 kg/ha)	11.92	21.67	32.47	35.84	9.36	47.97	143.61	310.92	1.28	4.69	5.57
P_2 (P_2O_5 @ 60 k/ha)	13.14	24.17	35.66	39.67	11.67	70.85	235.43	414.38	1.97	5.23	5.75

P_3 (P_2O_5 @ 80 kg/ha)	13.78	24.59	35.90	40.39	13.14	80.52	262.86	435.61	2.19	5.82	5.96
S Em (±)	0.40	0.66	0.85	1.10	0.29	1.60	4.08	12.79	0.06	0.16	0.18
CD (5%)	1.18	1.93	2.48	3.49	0.83	4.68	11.91	37.32	0.18	0.47	0.53

Table: 1 (a) Interaction effect of different bio-control agents and phosphorus doses dry matter accumulation (g m-2) of chickpea

Treatments (30 DAS)		P_0	P_1	P_2		P_3
B_0		3.84	5.79	8.23		10.11
B_1		5.15	9.31	11.12		12.83
B_2		5.46	9.12	11.33		11.96
B_3		6.69	13.23	16.01		17.64
(B×P)	S Em (±)	0.57		(P×B)	S Em(±)	0.54
	CD (5%)	1.67			CD (5%)	1.64
Treatments (60 DAS)		P_0	P_1	P_2		P_3
B_0		24.69	33.63	49.66		66.66
B_1		32.35	44.24	66.58		81.62
B_2		32.46	42.58	65.07		69.94
B_3		39.98	71.42	102.08		103.88
(B×P)	S Em +	3.20		(P×B)	S Em +	3.06
	CD (5%)	9.36			CD (5%)	9.24
Treatments (90 DAS)		P_0	P_1	P_2		P_3
B_0		69.29	99.50	170.13		201.89
B_1		90.20	114.02	205.30		234.39
B_2		87.58	112.50	200.86		240.17
B_3		150.28	248.42	365.42		375.01
((B×P)	S Em +	8.16		(P×B)	S Em +	8.25
	CD (5%)	23.82			CD (5%)	25.27

Table 1(b): Interaction effect of bio-control agents and phosphorus doses on crop growth rate (gm-2 day-1) 90 DAS to harvest of chickpea.

Treatments (90 DAS-harvest)		P_0	P_1	P_2		P_3
B_0		3.74	4.04	4.53		3.78
B_1		3.08	4.67	4.66		3.91
B_2		4.22	5.89	6.74		6.78
B_3		4.64	7.69	7.93		8.56
(B×P)	S Em (±)	0.36		(P×B)	S Em (±)	0.37
	CD (5%)	1.06			CD (5%)	1.15

(Bio-control agents - B_0 - No inoculation, B_1- *Pseudomonas fluorescens*, B_2- *Trichoderma harzianum*, B_3- *Pseudomonas fluorescens* + *Trichoderma harzianum*., Phosphorus levels - P_0 - Control, P_1- 40 kg P_2O_5 ha^{-1}, P_2 - 60 kg P_2O_5 ha^{-1}, P_3 - 80 kg P_2O_5 $ha^{-1,}$ RDF – 25 N: 40 K_2O kg ha^{-1})

Table 2: Effect of bio-control agents and phosphorus doses on number of branches per plant and root length(cm) of chickpea

Number of branches per plant								Root length (cm)			
Main plot (bio-control agents)											
	30 DAS	60 DAS		90 DAS		At harvest		30 DAS	60 DAS	90 DAS	At harvest
Treatments	Primary branch	Primary Branch	Secondary branch	Primary Branch	Secondary branch	Primary branch	Secondary branch				
B_0 (No inoculation)	2.35	3.46	3.60	4.33	5.70	4.44	5.94	6.01	9.93	15.85	16.81
B_1 (*Pseudomonas fluorescens*)	2.55	3.65	4.01	5.49	7.41	5.90	8.09	6.88	10.69	16.50	17.54
B_2 (*Trichoderma harzianum*)	2.44	3.67	3.75	4.79	6.37	4.99	6.50	6.74	11.66	17.57	18.43
B_3 (*Pseudomonas fluorescens +Trichoderma harzianum*)	2.89	4.07	5.43	6.22	8.67	6.56	9.15	9.94	14.53	19.73	21.49
S Em (±)	0.07	0.13	0.13	0.16	0.25	0.20	0.21	0.29	0.31	0.58	0.65
CD (5%)	0.25	0.44	0.44	0.56	0.85	0.68	0.74	1.01	1.08	NS	2.25
Sub plot (phosphorus)											
P_0 (Control)	1.95	3.01	3.53	4.04	4.75	4.58	5.11	5.74	8.98	13.88	15.88
P_1 (P_2O_5 @ 40 kg/ha)	2.61	3.49	3.74	5.00	5.72	5.13	6.08	7.27	10.66	16.20	18.17
P_2 (P_2O_5 @ 60 kg/ha)	2.78	4.15	4.51	5.78	8.71	5.97	9.04	7.93	13.33	19.36	20.02
P_3 (P_2O_5 @ 80 kg/ha)	2.89	4.20	5.01	6.00	8.96	6.22	9.46	8.64	13.84	20.20	20.10
S Em (±)	0.07	0.06	0.16	0.21	0.12	0.18	0.25	0.28	0.35	0.83	0.61
CD (5%)	0.21	0.19	0.46	0.62	0.34	0.52	0.72	0.80	1.03	2.43	1.78

Table 2 (a). Interaction effects of bio-control agents and phosphorus doses on secondary branches of chick pea on 90 DAS

Treatments		P_0	P_1	P_2		P_3
B_0		3.76	4.01	7.25		7.79
B_1		5.24	5.34	9.67		9.36
B_2		4.43	4.68	7.92		8.46
B_3		5.57	8.86	10.0		10.24
(B×P)	S Em (±)	0.23		(P×B)	S Em(±)	0.32
	CD (5%)	0.67			CD (5%)	1.03

Table 3: Effect of bio-control agents and phosphorus doses on no. of pods per plant, no. of seed per pods, seed yield (kg ha-1), stover yield (kg ha-1) and harvesting index (%) of chickpea.

Treatment	No. of pods per plant	No. of seed per pods	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	HI (%)
Main plot (Bio-control agents)							
B_0 (No inoculation)	10.67	1.39	174.02	618.6	1231.6	1850.2	33.90
B_1 (*Pseudomonas fluorescencs*)	14.25	1.32	176.09	686.4	1336.1	2022.5	34.49
B_2 (*Trichoderma harzianum*)	12.17	1.36	173.35	775.6	1441.2	2216.8	35.28
B_3 (Pseudomonas *fluorescencs* + *Trichoderma harzianum*)	18.50	1.40	178.08	974.1	1722.7	2696.8	35.81
S Em (±)	0.41	0.05	2.68	27.54	47.16	67.96	0.95
CD (5%)	1.43	NS	NS	95.31	163.19	235.19	NS
Sub plot (Phosphorus)							
P_0 (Control)	8.79	1.34	171.32	623.2	1183.30	1806.5	34.73
P_1 (P_2O_5 @ 40 kg/ha)	11.54	1.31	172.67	702.2	1395.30	2097.5	33.85
P_2 (P_2O_5 @ 60 kg/ha)	17.34	1.38	179.12	853.3	1562.80	2416.1	35.25
P_3 (P_2O_5 @ 80 kg/ha)	17.92	1.42	178.43	876.0	1590.1	2466.1	35.64
S Em (±)	0.40	0.03	4.45	13.64	43.08	49.85	0.88
CD (5%)	1.16	NS	NS	39.81	125.76	291.05	NS

Table 3(a): Interaction effect of bio-control agents and phosphorus doses on seed yield kg ha-1 of chickpea.

Treatment		P_0	P_1	P_2		P_3
B_0		574	602.3	645.3		652.7
B_1		600	631.7	744.3		769.7
B_2		634.3	710.3	862.3		895.3
B_3		684.3	864.3	1161.3		1186.3
(B×P)	S Em (±)	27.28		(P×B)	S Em (±)	36.28
	CD (5%)	79.63			CD (5%)	117.24

(Bio-control agents - B_0 - No inoculation, B_1- *Pseudomonas fluorescens*, B_2- *Trichoderma harzianum*, B_3- *Pseudomonas fluorescens* + *Trichoderma harzianum*., Phosphorus levels - P_0 - Control, P_1- 40 kg P_2O_5 ha^{-1}, P_2 - 60 kg P_2O_5 ha^{-1}, P_3 - 80 kg P_2O_5 $ha^{-1,}$ RDF – 25 N: 40 K_2O kg ha^{-1})